Decarbonising The Future: The Roles of Malaysia's Quantity Surveyors In Carbon Efficiency

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ABSTRACT

The construction industry plays an imperative role in the social development and economic growth of a country. However, it also contributes to the carbon emissions that lead to critical climate change issues for the environment. Climate change brings a huge negative impact as it leads to instability of agricultural production, disruptive weather disasters, and public health challenges. Thus, all parties in the construction industry must take initiative toward reducing the carbon footprint to limit the rise of global temperature. Having a clear mind on the role and responsibility of all parties in the construction industry to minimise the carbon emissions is the keynote to decarbonise the construction industry. However, there is no research conducted on the expanded role of quantity surveyors in the carbon efficiency in Malaysia. This research aims to investigate the roles of Malaysia's quantity surveyors in carbon efficiency. The research methodology used is quantitative method by incorporating the findings from the literature and the questionnaire survey that was distributed to the targeted respondents, which are the quantity surveyors in Malaysia. 357 (S=357) samples are required to suit a total population of 5,496 (N=5,496) according to Krejcie & Morgan (1970), and 21.19% of responses were received. The collected data was analysed by using Statistical Package for Social Sciences (SPSS). According to the outcome of this research, Malaysia's quantity surveyors have a better understanding of decarbonisation concept and aware about the carbon emissions issue in Malaysian construction industry. The findings of this research firms the needs of quantity surveyors to involve in decarbonisation as it provides the construction players an overview of the roles of quantity surveyors in decarbonised construction as well as the suitable adaptation strategies to be implemented by quantity surveyors towards the decarbonise practices.

Keywords
Carbon efficiency, carbon emissions, decarbonisation, Malaysia, quantity surveyors (QS).

1 Introduction

The construction industry plays an imperative role in social development and economic growth of a country. However, it is also the main sector that contributes the carbon emissions to our environment, which cause the critical climate change issue to occur (Zhang and Wang, 2015). About 19% of the global greenhouse gases (GHG) emissions come from the construction industry, thus carbon reduction and energy conservation have become the serious matter (Mathur et al, 2021).

Global warming is one of the most relevant global sustainability issues nowadays, which caused by the carbon emissions. Global warming has negatively impact and leads to agricultural production instability, disruptive weather disasters, and the public health challenges (Mathur et al, 2021). Therefore, the joint efforts of all individuals, organisations and governments are required to overcome and mitigate the imminent climate change issue. It is crucial for all parties in construction industry to take positive initiative towards reducing their carbon footprint to limit the rise in global temperature to 1.5 degrees Celsius by year 2050 ("Chapter 4 - Our decarbonisation pathway," 2022).

Based on the Malaysia's Third Biennial Update Report submitted to the United Nations Framework Convention on Climate Change (UNFCCC) in 2020, the construction and manufacturing sector in Malaysia was the third largest contributor of carbon emissions at 9% in year 2016. Thus, it is urged that the reconsideration of the overall value chain together with the construction sector as we can find the existence of carbon footprint along the construction all the way via the operation of completed buildings and infrastructure. As example, the consumption of cement with high carbon emissions has contributed to 8% of global carbon emissions (Rodgers, 2018). There are various methods that Malaysia has adopted in minimizing carbon footprint. In 2016, the Public Works Department has adopted the Malaysian Carbon Reduction and Environmental Sustainability Tool (My Crest) and has mandated for all government building projects that worth RM50mil and above with the purpose of minimizing the carbon emissions in Malaysian construction industry (Ahmad Naqib Idris, 2016). Moreover, a 5-year plan of promoting low carbon cities was launched in Malaysia, namely the National Low Carbon Cities Masterplan (NLCCM), which involved 33 cities to achieve carbon neutrality. It is expected that 50% of energy to be saved for all 33 cities in NLCCM plan ("Third Biennial Update Report to the UNFCCC," 2020).

From the literature, there are limited studies on how the construction industry can meet their decarbonization target in year 2050. As one of the key players in the construction industry, the QS have a very important roles in quantifying the embodied carbon emission throughout the construction lifecycle (Grant Warner, 2022). Several research highlighted the roles of architect, engineer, and project manager in decarbonising (Ong et al,2020; Reza,2017). However, there is no detailed study of how Malaysia's QS can contribute themselves in decarbonising to achieve net carbon neutral target by year 2050. Thus, this led to uncertainties about how the Malaysia's QS should play their roles in reducing carbon footprint. In addition, most of the publications focus on the methods used to achieve carbon efficiency in foreign countries such as China and Korea. The current decarbonisation pathways used in Malaysian construction industry is yet to be studied. Thus, there is a need to investigate the roles of Malaysia's QS in carbon efficiency and decarbonising Malaysian construction industry.

1.1 Research Background

With the increasing accumulation of GHG, the impact of global warming has become more serious and the average temperature levels are surpassing annually. Melting ice at unprecedented levels and the frequent of extreme natural disasters to occur has increase. Various researchers proven that the massive quantities of greenhouse gases are the main cause of climate change and it has been defined as the man-made phenomenon (Jackson, 2020; Monahan, 2013). Thus, it is utterly important to reduce the greenhouse gases especially from the construction industry (Mathur et al, 2021).

Various research on carbon footprint management can be found in the developed countries, such as China, Korea, United Kingdom, and United States (Du et al.,2019; Emma et al.,2015; Kang et al.,2015; Christopher et al.,2015). However, according to Mathur et al (2021), there is insufficiency of research on the carbon footprint management in Malaysian construction industry which lead to the low awareness level of QS towards the decarbonisation. Carbon footprint management can mitigate carbon emissions from the construction activity to minimize their impact on the climate changes. The measurement of the carbon footprint for buildings can be carried out based on five elements, which are the construction materials production and transportation, construction process, demolition, direct energy usage, and the waste disposal. However, not much effort taken by construction industry in capturing the overall possible carbon emissions and exploring the carbon reduction methods ((Mathur et al, 2021). Hence, it is imperative to determine the current carbon footprint management in Malaysian construction industry for achieving carbon efficiency.

Meanwhile, Omotayo et al (2022) recommended to carry out the study on the changing roles of QS in the context of the sustainable construction with the purpose of enhancing the current review on the roles of QS. It is because QS plays crucial role in the construction industry, starting from the pre-construction stage until the post construction stage (Omotayo et al., 2022). According to Omotayo et al (2022), there is lack of identification of the roles of QS in the emerging sustainable construction. Furthermore, Seidu et al (2019) pointed out that the absence of methods adopted by QS to change their roles to cope with the new decarbonised construction and achieve the carbon efficiency of buildings. This statement is supported by a previous study conducted by Wong (2021) that there is lack of awareness of QS in social responsibility and sustainable construction. Referring to the aforementioned research, QS plays a vital role in achieving carbon efficiency and decarbonising the Malaysian construction industry. Thus, there is an urgent need to explore the adaptation way for Malaysia's QS to the new decarbonised construction and the expanded roles of Malaysia's QS under the sustainable construction scope.

Thus, there is a lack of research on the expanded role of QS in carbon efficiency of buildings that enables the Malaysian construction industry to achieve the target of net zero carbon in year 2050. Therefore, this research is crucial to address these problems and help to identify the full potential of QS to perform their roles in carbon efficiency of buildings in Malaysia. Additionally, this research will increase the awareness of QS in the effect of carbon on the wide range of quantity surveying practices in Malaysian construction industry.

1.2 Research Aim and Objectives

The aim of the research is to investigate the roles of Malaysia's quantity surveyors in carbon efficiency. Four research objectives are identified as follows,

i. To identify the awareness of quantity surveyors towards the decarbonisation in Malaysian construction industry.
ii. To determine the roles of Malaysia's quantity surveyors in decarbonisation.
iii. To evaluate the technique of adaptation to the decarbonised construction by quantity surveyors in Malaysia.
iv. To suggest the adaptation strategy of Malaysia's quantity surveyors towards the decarbonisation practice.

2 Literature Review – Overview of QS

QS is a construction industry professional that provides services across many industries globally. In the construction industry, QS are involved in all stages of project throughout the whole lifecycle, starting from feasibility stage, design stage, construction stage, refurbishment stage, maintenance stage, and demolition stage. Construction products that can achieve clients' requirements and value system is the main target set by the QS. QS involves in different areas of construction industry, such as procurement and contractual area, cost management area, and strategic planning area. In other words, QS plays different roles in different work aspects of construction industry (Abdul & Paul, 2015).

2.1 Basic roles of QS

The roles of QS start from the preliminary stage until the post-construction stage of a construction project, Table 1 shows the basic roles of QS.

Table 1. Basic roles of QS

Basic roles of QS	Authors
Prepare preliminary cost estimation and cost planning	RISM (2022); Sheikh et al. (2021); Salleh et al. (2020); Mohd Noor et al. (2020); PAQS (2019); Wong (2017); Babu (2015)
Prepare cost schedules	Sheikh et al. (2021); Salleh et al. (2020); Mohd Noor et al. (2020); PAQS (2019); Babu (2015)
Advice on procurement, tendering and contractual procedures	RISM (2022); Sheikh et al. (2021); Salleh et al. (2020); Mohd Noor et al. (2020); Wong (2017); Jalil et al. (2017); AbdulLateef et al. (2015)
Prepare bill of quantities and specifications	RISM (2022); Sheikh et al. (2021); Salleh et al. (2020); PAQS (2019); Wong (2017); Babu (2015); AbdulLateef et al. (2015); Chong (2014)
Prepare tender documents and organize the tendering process	RISM (2022); Sheikh et al. (2021); Salleh et al. (2020); AbdulLateef et al. (2015)
Evaluate tender reports and tender negotiation	RISM (2022); Salleh et al. (2020); Babu (2015); AbdulLateef et al. (2015)

2.2 Additional roles of QS

Besides the basic roles of QS as explained above, QS also provides additional roles as listed in Table 2 below.

Table 2: Additional roles of QS

Additional role of QS	Author
Prepare feasibility studies	RISM (2022); Salleh et al. (2020); Mohd Noor et al. (2020); PAQS (2019); Wee (2017); Wong (2017)
Estimate the expenditure of project and development	RISM (2022); Salleh et al. (2020); AbdulLateef et al. (2015)
Evaluate registered contractors for prequalification	RISM (2022); Salleh et al. (2020)
Life cycle costing	RISM (2022); Sheikh et al. (2021); Salleh et al. (2020); Mohd Noor et al. (2020); PAQS (2019); Wong (2017); Babu (2015); AbdulLateef et al. (2015)
Cost benefit analysis	Sheikh et al. (2021); Salleh et al. (2020); Wee (2017)
Price bills of quantities (BQ) and negotiate on the contract rate	RISM (2022); Salleh et al. (2020); Wee (2017)
Project management	Sheikh et al. (2021); Mohd Noor et al. (2020); PAQS (2019); Wee (2017)
Risk management	Salleh et al. (2020); PAQS (2019); Wee (2017)
Value management / Value Engineering	Salleh et al. (2020); Mohd Noor et al. (2020); PAQS (2019); Wee (2017); Wong (2017)
Facilities management	Salleh et al. (2020); Mohd Noor et al. (2020); Wee (2017)
Quality management	Sheikh et al. (2021); Salleh et al. (2020); PAQS (2019)
Insurance valuation	RISM (2022); Sheikh et al. (2021); Salleh et al. (2020); Wee (2017)
Tax adviser	Sheikh et al. (2021); Salleh et al. (2020); Wee (2017)
Arbitrator or mediator for dispute resolution.	Sheikh et al. (2021); Wee (2017); Babu Reddy (2015)
Premises and technical audits	Wee (2017); Babu Reddy (2015)
Valuation of contractual claim for litigation	RISM (2022); Salleh et al. (2020)

2.3 Expanded roles of QS in green construction

Furthermore, QS also involved in green construction. Table 3 summarises the expanded role of QS in green construction.

Table 3: Expanded roles of QS in green construction

Expanded role of QS in green construction	Description
Green costing	The technologies that emerged are being adopted in green buildings and the related costs.
Carbon footprint	The current level of carbon emissions is being measured by adopting the carbon management strategy.
Life cycle costing	Cost management of building throughout the life cycle.
Property performance reporting	Report submitted by the building owners to know the existing performance measurement tools and understand how to meet new standards.
Green building rating assessment	Advice clients on sustainable designs and costing.
Building Information Modelling (BIM)	The integral management platform for the information throughout the lifecycle of project.

Source: Salleh et al (2020); Wong (2017)

2.4 Carbon emissions

The main greenhouse gas emitted to the environment is carbon dioxide (CO2), which also known as carbon emissions. CO2 is naturally occurred in the atmosphere, such as the natural circulation of carbon among the atmosphere, soil, plants, oceans, and animals (Overview of Greenhouse Gases, 2022). Carbon emissions are determined and recorded as elemental carbon with KT (kiloton) as the unit of measurement. The carbon emissions in Malaysia escalated from 244,410 KT in 2018 to 253,270 KT in 2019, consisting of gases from the cement manufacture and the burning of fossil fuels (Malaysia CO2 Emissions, 2022).

2.4.1 Carbon emissions issue in Malaysia

Carbon emissions has turned out to be a serious problem in Asian countries that are experiencing rapid urbanisation, such as China, Malaysia, and Singapore. In Malaysia, the construction industry is the main contributor of carbon emissions as it brings huge amounts of carbon emissions to the country (Fujita et al.,2009).

Based on the research by Safaai et al. (2011), the population in Malaysia contribute to the carbon emissions, where there was 68.86% increase in the level of carbon releases as compared to the level of carbon emissions in earlier years. Furthermore, the gross domestic product (GDP) in Malaysia also contributed to the carbon emissions level. (Safaai et al.,2011).

According to Zolfagharian et al. (2012), Malaysian construction industry has negatively impacted the ecosystem by 67.5% due to the construction activities. Not only that, it also affects the public by 11.5% and the natural resources by 21% respectively. The quality of

human life and the natural environment are highly affected by the construction in Malaysia as the impacts brought by the Malaysian construction industry are irreversible and directly affect the different areas (Zhang et al., 2020). Figure 1 illustrates the relationship between construction output and CO2 emissions in Malaysia. It shows that the carbon emission in Malaysia have been steadily increasing from 2000 to the first quarter of 2023 without any significant declines, despite a decrease in construction output, especially during 2019 till 2021 due to COVID-19 pandemic. Therefore, there is a need in Malaysia to control and manage the carbon emissions from the construction activities. However, there is lack of initiatives by Malaysia to reduce the carbon footprints from the construction industry (Esmaeilifar, 2017).

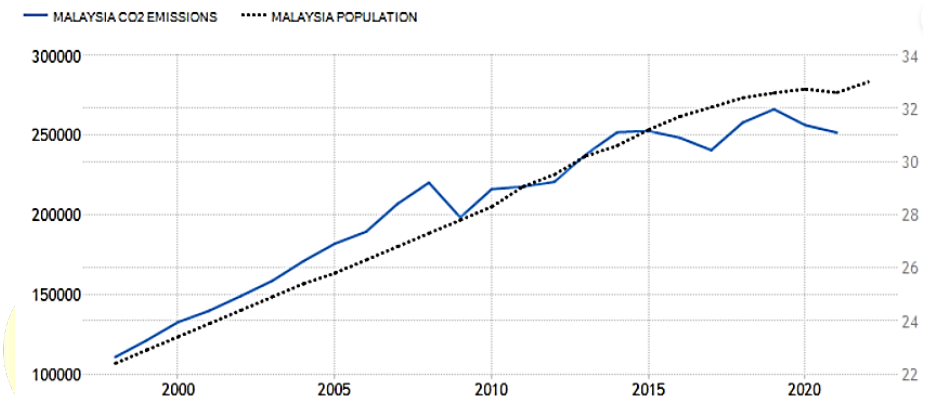

Figure 1. Relationship between construction output and CO2 emissions in Malaysia (Malaysia CO2 Emissions, 2023)

2.5 Decarbonisation pathways

The reduction of GHG emissions into the environment is known as decarbonisation. The term decarbonisation consists of the word carbon because the carbon dioxide (CO2) is the largest contributor to this issue, but it also refers to the reduction of other gases such as nitrous oxide (N2O), ozone (O3), and methane (CH4) (Why Is Decarbonisation Important?, 2022). Decarbonisation is crucial in decelerating the climate change issue by eliminating the greenhouse gas emissions into the atmosphere. 39% of global greenhouse gas emissions come from the building construction sector, consisting of 28% of operational emissions and 11% of construction and building materials (Decarbonizing Construction: The What, Why, and How, 2022). Therefore, it is imperative for the acceleration of decarbonisation in the construction industry, especially for the building construction sector.

2.5.1 Decarbonisation pathways adopted by Malaysia

The implementation of decarbonisation has been carried out by Malaysia in several sectors, such as the energy, transportation, waste, and forestry. Based on the Malaysia's latest biennial update report to the UNFCCC in 2020, Malaysia has implemented the Feed-in-Tariff programme, hydropower projects and other renewable energy generation projects, in which the GHG emissions avoidance of 7,262,59 Gg CO2-eq in energy sector. Not only that, the implementation of palm-based biodiesel in Malaysia also eliminated 1,127.34 Gg CO2-eq in energy sector while the National Energy Efficiency Action Plan brought a positive impact in

decarbonisation by mitigating 458.02 Gg CO2-eq ("Third Biennial Update Report to the UNFCCC," 2020).

In the transportation sector, the rail-public transport had avoided 212.93 Gg CO2-eq and the natural gas vehicles had reduced 114.77 Gg CO2-eq. Furthermore, the usage of hybrid and electric vehicles in Malaysia also eradicate 90.65 Gg CO2-eq. The decarbonisation pathway of Malaysia also involved in the waste sector, where the recycling of wastepaper brought significant reduction of greenhouse gas emissions at 3,937.76 Gg CO2-eq and the recovery of biogas from palm oil mill effluent avoided 2,377.84 Gg CO2-eq. In addition, Malaysia also contributed the decarbonisation in forestry sector by implementing sustainable management of permanent reserved forest and sustainable harvesting of timber. The enrichment programme and protected areas for forest also increased which helped in the reduction of greenhouse gas emissions at 20,307.50 Gg CO2-eq ("Third Biennial Update Report to the UNFCCC," 2020).

Several research highlighted the decarbonisation pathways adopted by other countries, such as China, United Kingdom, Europe, and United States (Kevin et al.,2008; Wu et al.,2016; Du et al.,2019; Favier,2018). However, there is lack of decarbonisation pathways in Malaysian construction industry.

3 Methodology

To achieve the aim and objectives of this research, the adopted method to collect primary data is entirely quantitative which incorporates the use of questionnaire survey that will be distributed to the targeted respondents. The questionnaire survey has been chosen as the strategy of data collection due to the limitation of time given for conducting this research. The secondary data will be gathered by reviewing the existing literature and data available on numerous secondary sources.

3.1 Primary Data Collection: Literature Review

Literature review is conducted to gather secondary data and at the same time it helps the researcher to identify and have a better understanding to the relevant knowledge of the research area. The way of conducting literature review is mainly through searching of scientific references available via university subscribed databases such as ScienceDirect, Emerald, JSTOR, ResearchGate and EBSCO. Moreover, sources such as Google Scholar is utilised to gain more key points, relevant information, concepts, and terminologies. Literature review is crucial as it helps the researcher to acquire adequate knowledge of the research area in order to ease the process of collecting primary data. In short, a sufficient literature review can spot the issue under consideration, disclose the essential purpose of the research, and deliver the relevant information of the research while conclude the research by conveying the significant results that related to the research.

3.2 Secondary Data Collection: Questionnaire Survey

The online questionnaire method is adopted as the quantitative approach for collecting the primary data as a huge number of participants are involved in this research. The research surveys are highly used as the information and data can be collected directly in the shortest

time and a large sample can be utilised (Chiang, 2015). Not only that, the research surveys are practical and suitable for this research due to the time constraints of this research. The questionnaire is distributed to the targeted respondents via online platforms, such as email and phone message.

This research focuses on the roles of Malaysia's QS in carbon efficiency. Thus, the research determines the scope and chooses the suitable respondents. The respondents that will be approached are the registered QS with the Board of Quantity Surveyors Malaysia (BQSM) and the overall population size is based on the official website, shown in Table 3 below.

Table 4: Population size of targeted respondents

Targeted Respondents	Population Size (N)
Quantity Surveying Technologist	101
Provisional Quantity Surveyor	3,656
Professional Quantity Surveyor	591
Consultant Quantity Surveyor	1,148
Total	**5,496**

Source: BQSM (Jan, 2023)

The sampling size determination table by Krejcie and Morgan (1970) was adopted to overcome the problem of large number respondents in this research. Thus, the required sample size is 357 (S=357), according to the total population size of 5,496 (N=5,496).

3.3 Data Analysis

The response rate was 21.19% where 420 sets of questionnaires were sent out and 89 sets were completed and returned. According to Dulami et al (2003), the response rate from the construction industry is around 20% to 30% while Idrus et al. (2008) opine that the norm response rate for the questionnaire survey from the construction industry is 5% to 15%. Therefore, the response rate of 21.19% from the construction industry is common and acceptable.

Cleaning of raw data was conducted to reduce inconsistencies. The outliers of data were detected by using boxplots, followed by assessing the internal consistency of the scale using Cronbach's Alpha. The roles of QS in carbon efficiency displayed excellent internal consistency, with Cronbach's Alpha of 0.932. Next, the mean and standard deviation for each item were calculated to determine the significance of the QS's roles in carbon efficiency. The items were then ranked from the highest mean to the lowest mean, using relative importance index (RII).

The normality of data collected was then tested by using Kolmogorov-Smirmov test. Visual inspection has also been adopted in testing the normality of data. The Kruskal-Wallis test was conducted at a confidence interval of 95% to test the hypotheses. It is the extension to the Mann-Whitney test as it can test more than two independent variables, and also it is a non-parametric alternative to the one-way ANOVA. The hypotheses created were as follows:

H0. There is no significant difference between the roles of quantity surveyors in decarbonisation based on respondents' experience in decarbonisation.

H1. There is a significant difference between the roles of quantity surveyors in decarbonisation based on respondents' experience in decarbonisation.

4 Findings and Discussion

Table 5 shows that most of the respondents had 1 to 5 years' experience (39.33%) and more than 20 years' experience (20.22%) in construction industry, indicating that more knowledge were shared by them in various point of view. Table 5 further reveals that the majority of the respondents (59.55%) had no experience in decarbonisation even though 42.70% of respondents have high level of understanding in decarbonisation. Also, none of the respondents has involved in decarbonised construction projects more than 10 years, indicating that decarbonisation is a new concept to Malaysia construction industry.

Table 5: Background information of respondents

Variables	Level	Percent
Years of experience in construction industry	Less than 1 year	14.61
	1 – 5 years	39.33
	6 – 10 years	6.74
	11 – 15 years	14.61
	16 – 20 years	4.49
	More than 20 years	20.22
Current knowledge and understanding in decarbonisation	Low	38.20
	Medium	4.49
	High	42.70
	Very high	0.00
Years of experience in decarbonisation	No experience	59.55
	Less than 1 year	23.60
	1 – 5 years	13.48
	6 – 10 years	3.37
	More than 10 years	0.00

4.1 The roles of QS in decarbonisation

Table 6 shows the results of Kruskal-Wallis test and RII ranking for the roles of QS in decarbonisation. There is significant difference for the quantity surveyors' roles in decarbonisation among different categories of respondents' experience in decarbonisation based on the Kruskal-Wallis test. The "life cycle costing analysis (LCC)" and "building performance reporting" have different distribution across the categories of respondents' experience in decarbonisation as its significant value is lesser than 0.05, which are 0.042 (p=0.042) and 0.012 (p=0.012) respectively.

The null hypotheses of both statements mentioned have been rejected as their significant values are less than 0.05. It is because the life cycle costing analysis (LCC) is not only had to be performed by QS in decarbonisation but in any construction projects as it is the additional role of QS (RISM,2022; Sheikh et al,2021; Salleh et al,2020; Mohd Noor et al,2020; PAQS,2019; Wong,2017; Babu,2015; AbdulLateef et al,2015). On the other hand, preparing building performance report is not the roles of QS in decarbonisation as it ranked last in RII ranking. This statement is aligned with the findings of Salleh et al (2020) and Wong (2017) that the building performance reporting shall be done and submitted by the building owners

instead of QS. Based on the submitted reports, QS then only can understand the existing performance measurement tools and know how to meet new standards (Salleh et al,2020; Wong,2017).

Besides the above-mentioned statements, the other 14 roles of quantity surveyors in decarbonisation have no significant differences based on the respondents' experience in decarbonisation. Their significant values are greater than 0.05, and thus the null hypothesis can be retained. The roles of QS in assisting team to updated cost estimation has the highest significant value of 0.996 (p = 0.996) and ranked first in RII ranking with the highest mean value of 4.157 among all the roles as it is the vital role of QS in decarbonisation. Without updated estimation of cost, the chance for construction projects to fail is very high, especially for new decarbonised projects (Wong,2017; Salleh et al,2020). Thus, majority of the respondents agree that assisting team in updated cost estimation is the roles of QS in the field of decarbonisation.

In short, the Kruskal-Wallis test indicates that majority of the QS's roles in decarbonisation do not have significant differences based on the experience of respondents in decarbonisation. Only the life cycle costing analysis (LCC) and building performance reporting have significant differences and thus the null hypothesis for both statements have been rejected.

Table 6: Kruskal-Wallis test and RII ranking for the roles of QS in decarbonisation

The roles of QS in decarbonisation	Kruskal-Wallis Test		Relative Importance Index		
	Significance value	Decision	Mean	RII	Rank
Assist team in updated cost estimation	0.996	Retain H0	4.157	0.8315	1
Assist team to set realistic budget	0.912	Retain H0	4.101	0.8202	2
Life cycle costing analysis (LCC)	0.042	Reject H0	4.022	0.8045	3
Cost benefit analysis (CBA)	0.157	Retain H0	4.011	0.8022	4
Cost estimation for each building design iteration	0.926	Retain H0	4.011	0.8022	4
Review final bid documents with the design team	0.719	Retain H0	3.978	0.7955	6
Green costing	0.626	Retain H0	3.921	0.7843	7
Building information modelling (BIM)	0.833	Retain H0	3.921	0.7846	7
Ensure both costs and credits for low carbon features are accounted for	0.259	Retain H0	3.843	0.7685	9
Low carbon materials pricing and cost estimation	0.709	Retain H0	3.831	0.7663	10
Value engineering on low carbon materials to be used for the project	0.662	Retain H0	3.798	0.7596	11
Maintain database for low carbon building products from various specialists and suppliers	0.407	Retain H0	3.685	0.7371	12
Carbon footprint management	0.596	Retain H0	3.427	0.6854	13
Low carbon footprint strategy development	0.982	Retain H0	3.371	0.6742	14
Low carbon building rating assessment	0.632	Retain H0	3.303	0.6607	15
Building performance reporting	0.012	Reject H0	3.191	0.6382	16

Null hypothesis (H0): The distribution of variable is same across the categories of respondents' experience in decarbonisation.

4.2 The awareness level of QS towards decarbonisation in Malaysia

Table 7 displays the RII ranking for the awareness level of QS towards decarbonisation in Malaysia. "QS is aware about the sustainable construction", "QS is aware that the carbon emission issue brings huge negative impact", and "QS is aware about the serious global warming issues caused by carbon emissions" are listed as the top three statements, indicating most of the respondents showed their agreement to these three statements. These findings are supported by the research conducted by Crippa et al (2020), which mentions that the developed countries such as Japan, China, India, United States and etc have higher carbon emissions issues due to their advance industrial activities.

Furthermore, most of the respondents have similar opinion towards "QS is aware about the carbon emission issue from Malaysian construction industry" and "QS is aware about the social responsibility in the decarbonised construction industry" since they are ranking fourth and fifth respectively. The statement of "QS is aware about the decarbonisation pathways in Malaysian construction industry" ranked last in the RII ranking as it has the least value of RII. This finding is consistent with the research conducted by Esmaeilifar (2017), which highlights the lack of initiatives taken by Malaysian construction industry to minimise carbon footprints.

From the tabulated result, we can summarise that Malaysia's QS are aware of the carbon emissions issue in construction industry which brings huge negative impacts such as global warming and at the same time, they are aware of sustainable construction in Malaysia. However, Malaysia's QS still have low awareness level towards the decarbonisation pathways and their social responsibility in decarbonised construction industry.

Table 7: RII ranking for the awareness level of QS towards decarbonisation in Malaysia

The awareness level of QS towards decarbonisation in Malaysia	Relative Importance Index		
	Mean	RII	Rank
QS is aware about the sustainable construction.	3.809	0.7618	1
QS is aware that the carbon emission issue brings huge negative impact	3.708	0.7416	2
QS is aware about the serious global warming issues caused by carbon emissions	3.640	0.7281	3
QS is aware about the carbon emission issue from Malaysian construction industry	3.551	0.7101	4
QS is aware about the social responsibility in the decarbonised construction industry	3.169	0.6337	5
QS is aware about the decarbonisation pathways in Malaysian construction industry	2.989	0.5978	6

4.3 The technique of adaptation to the decarbonised construction by Malaysia's QS

Table 8 presents the RII ranking for each statement related to the techniques of adaptation by Malaysia's QS to the decarbonised construction, indicating the level of agreement expressed by the respondents. Based on observation, the statement ranked first with the highest RII is

"build up cost database by collecting costs from suppliers on decarbonisation services and products". This highlights the importance of cost management for QS in decarbonised construction. It is their fundamental role and utterly crucial in achieving a sustainable built environment (Sheikh et al.,2021; Salleh et al.,2020; PAQS,2019; Babu Reddy,2015). The second-ranked statement in RII is "sustainability education and knowledge (focusing on the reduction of carbon emissions)", which emphasises on the importance of knowledge and education in sustainability and decarbonisation pathways that are essential for quantity surveyors to adapt to the changing needs of the industry.

The third-ranked statement is "attend seminars on decarbonisation pathways", which further underscores the importance of continuing education in the field as knowledge is the springboard for quantity surveyors to adapt well to the decarbonised construction. Furthermore, the fourth and fifth-ranked statements in the RII are "lack of adaptation technique by QS to the decarbonised construction" and "enhancement of QS with related skills and knowledge in decarbonisation via research" respectively. These statements indicate that research may not be the most effective adaptation technique for quantity surveyors in enhancing their skills and knowledge in decarbonisation. However, the adaptation techniques currently adopted by QS to decarbonised construction are sufficient at present (Waniko,D., 2022).

Table 8: RII ranking for the technique of adaptation to the decarbonised construction by QS

The technique of adaptation to the decarbonised construction by Malaysia's QS	**Relative Importance Index**		
	Mean	**RII**	**Rank**
Build up cost database by collecting costs form suppliers on decarbonisation services and products	4.202	0.8404	1
Sustainability education and knowledge (focusing on the reduction of carbon emissions)	4.079	0.8157	2
Attend seminars on decarbonisation pathways	3.989	0.7978	3
Lack of adaptation technique by QS to the decarbonised construction	3.966	0.7933	4
Enhancement of QS with related skills and knowledge in decarbonisation via research	3.944	0.7888	5

4.4 The suggested adaptation strategies towards the decarbonised construction

Table 9 presents the percentage ranking for the suggested adaptation strategies towards the decarbonised construction. The "involvement in decarbonisation related projects" is suggested by most of the respondents as the most suitable strategy for the adaptation towards the decarbonised construction as it has the highest percentage of 32.63% (N = 77). This preference stems from the understanding that QS gain direct experience and knowledge related to decarbonisation by actively participating in such projects as the decarbonisation trend provides both risk and opportunity to QS (Glodon,2022). Furthermore, "decarbonisation related activities by QS professional bodies" is considered as the second most suitable adaptation strategy, with a percentage of 24.15% (N = 57). Professional bodies play a crucial role in guiding the quantity surveyors towards the correct ways of adapting to the decarbonisation trend through their dedicated activities in this area.

Next, "courses" and "seminars" have also been suggested by the respondents as the viable strategies for adapting to the decarbonised construction, with a percentage of 21.19% (N = 50) and 20.76% (N =49) respectively. These educational avenues that serve as the imperative platforms for QS to acquire new knowledge and gain a deeper understanding of

decarbonisation concepts. This is because the requirement of carbon assessment such as cost reporting and controlling has aligned to the skills of QS (Glodon,2022). Lastly, "government to mandate rules and regulations towards the decarbonised construction industry" receives the least respond as the adaptation method to the decarbonised construction industry as it only has a percentage of 1.27% (N = 3). This is because the respondents perceive that it is challenging for the government to create and enforce the new rules and regulations specifically towards the decarbonised construction industry.

Table 9: Percentage ranking for the suggested adaptation strategies towards the decarbonised construction

The suggested adaptation strategies towards the decarbonised construction	Respondent		Rank
	N	Percent	
Involvement in decarbonisation related projects	77	32.63	1
Decarbonisation related activities by QS professional bodies	57	24.15	2
Courses	50	21.19	3
Seminars	49	20.76	4
Government to mandate rules and regulations towards the decarbonised construction industry	3	1.27	5

5 Conclusions

This research studied the roles of Malaysia's QS in decarbonisation and identified the current awareness level of QS towards decarbonisation. The technique of adaptation by QS towards the decarbonised construction has been evaluated and suggested too. The main finding of this research shows that Malaysia's QS have certain level of understanding on their roles in decarbonisation. The top five QS's roles in decarbonisation are assisting team in updated cost estimation, assisting team to set realistic budget, life cycle costing analysis (LCC), cost benefit analysis (CBA), and cost estimation for each building design iteration. On the other hand, the roles of QS least related to decarbonisation are building performance reporting, low carbon building rating assessment, and low carbon footprint strategy development.

Based on findings, QS in Malaysia have low awareness level towards decarbonisation pathways and their social responsibility. The most common adaptation strategy used by QS is build up cost database by collecting costs from suppliers on decarbonisation services and products while involving in decarbonisation related projects has been suggested by the respondents as the most suitable adaptation strategies towards decarbonised construction. Another important finding of this study is that QS tend to perceive the significance of QS's roles in decarbonisation differently based on their experience in decarbonisation.

These findings have contributed to the body of literature on the roles of QS in decarbonisation as it provides better understanding of the roles of QS in decarbonised construction. Subsequent research could employ this study as a foundation and devise adaptive strategies for QS in decarbonised construction. From practical viewpoint, it has highlighted the most related roles of QS and adaptation strategies. Thus, this research can be used as reference for Malaysia's QS to adapt themselves towards the decarbonised construction so that they are competent to carry out their duties more effectively and efficiently.

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